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INTRODUCTION TO MAGNETS FOR LOWER PRIMARY SCHOOL STUDENTS

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Abstract:
This paper presents the findings of a research concerning the introduction to magnets and elementary magnetic properties in lower primary school children in a Piagetian perspective. Seven to eight 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 research question was whether children after a free but supported activity could discover the attractive force exerted on certain iron materials, distinguish the objects which were not thus attracted and discover the mutual forces of interaction by using the magnets. The teachers observed the activities, encouraged, 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 lead to positive answers.

Keywords: magnets, elementary magnetic properties; lower primary school

1. Introduction

The curricula of early childhood and primary education almost always include activities related to sciences. A category of programs includes activities and research based on the Piagetian perspective on knowledge construction (Appel, 1997; Kamii & DeVries, 1993; Ravanis, 2000, 2010). This concerns a framework produced by pedagogues and researchers who accept the Piagetian theoretical framework. 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. In this context, and according to research results, the proposed activities help children interact with the selected teaching material in appropriately constructed pedagogical and educative

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milieus. Thus, children are helped in the construction of physical knowledge. For example, Kamii (1982) proposes elementary activities for the early childhood and primary education with main objectives the transposition and transformation of objects. A similar approach from Crahay & Delhaxhe (1988) and Nertivich (2014) proposes the introduction of children to elementary properties of certain objects (such as spirals, magnets and inclined planes). Nevertheless, 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 we know, a fundamental topic of Piaget's theory is that the development of human intelligence is the result of the activity of the subject on the objects of the material world and not of the amorphous, sensory perception of data of the natural and social environment (Piaget, 1950, 1967, 1970). Accordingly, it is expected that teaching approaches based on Piagetian epistemology 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 general, with respect to the constitution of physical knowledge, the educational procedures suggested for children have the above mentioned characteristics. At the center of these procedures stands the free but prudently supported initiative of the children, with the teachers playing a specific, encouraging and questioning part in the teaching practice.

Kamii (1982) and Kamii & De Vries (1993) express the opinion that at preschool and lower school age we should juxtapose the "construction of physical knowledge" with the "teaching of science". The teaching of physics, chemistry or biology focuses on the object to be taught, the theories, the models and the concepts of science, specialized terminology and scientific methodology. In contrast, the teaching practices of physical knowledge focus on the progress of the child's activities and its discoveries. Kamii & De Vries (1977) suggest a frame of educational principles based on Piagetian epistemology.

> *"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".*
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> (Nertivich, 2014, p. 2)

Within a parallel theoretical context, the free activity of children in a school setting rich in didactic material, Crahay & Delhaxhe (1988) and Nertivich (2014) observed that the approach to the objects of the environment is constantly achieved by the children in a constant order. Children set aims on the basis of which they organize actions or plans and get some results. These aims were either set at the opening or throughout the haphazard use of the objects. Thus, teaching design suggests a series of actions including the following parts:

1) *Estimates and expectations of the teacher or researcher preceding to the teaching activity.* At first, the teachers or researchers are responsible for the selection of the subject of activities. Consequently, they are also responsible for defining the nature of the material to be used, as well as the classrooms or the laboratory required or their preparation. The chosen teaching objectives should offer the possibility of interaction with material and should not be taken at random from everyday life. As soon as the teacher selects the objects and the material, s/he should attempt some estimates about the quality level of the children's activity or the opportunity of their shown creativity, so as to be in a situation to encourage their own ideas, help them go beyond any failures and suggest new activities. That is, s/he should articulate a prognostic plan for each child on the basis of which s/he will observe the whole process.

2) *Throughout the teaching procedure.* Teachers or researchers present the material to the children, without presenting them how to use it. As soon as the children become familiarized with these materials, they start forming simple forms, that is, small manufactures, images of objects, etc. At this part the teacher notices and observes the actions of the children and records their activities, problems and failures as objectively as possible. The teacher asks them about their aims and inspires them if they succeed in achieving a preferred effect. When the teacher finds out that they fail in realizing their aims or when the teacher estimates that mediation by adults is crucial in order to set more complex aims, s/he intervenes according to either the plans s/he had expected or an unpredicted development.

3) *Examination after the teaching procedure.* After the teacher or researcher has collected remarks on the children's activities, with or without his/her intervention, s/he may then examine, 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 considers the free activities, s/he should locate the results of his/her own attitude, whether this consists of encouragement or questioning or of specific mediation. This examination is simplified 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 troubles?", 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 occasion 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 troubles, they may try to methodically deal with them. Such interventions lead the children to successful activities as regards both the results of their actions and their intellectual formation.

The above proposed strategies move in the same direction, since, on accepting Piagetian epistemological framework, they plan their activities around the supported, yet autonomous, interaction of the child with objects and substances of the environment. This study was set out 7-8 years old children's activities aiming to understand elementary magnetic properties (Haupt, 1952; Bailey, Francis & Hill, 1987; Barrow, 1987; Erikson, 1994; Borges, Tecnico & Gilbert, 1998; Guisasola, Almudi & Ceberio, 1999; Nertivich, 2013; Voutsina & Ravanis, 2013).

On the basis of the Piagetian strategies, we tried to study the results of the effort to organize teaching activities of lower primary school children working with magnets, the goal being their understanding of the properties of magnets which are included in the curriculum (Carruthers & de Berg, 2010).

This is precisely what we tried to do in our project. The research question was whether the children are able to discover during the activity:

1) the attractive forces exerted by magnets on certain materials,

2) the distinction between materials susceptible to magnetic forces from materials not susceptible to such forces,

3) the mutual attractive and repulsive action of magnets.

2. Methodological framework

2.1 Sample

Forty-eight children from 7 to 8 years of age (average age 7 years and 9 months) attending primary schools in Moscow, in districts of the same middle class social characteristics, participated in the research process. The children's parents had not received any special education in science. The children worked in four-member groups. In their classes, they did not participate in activities with magnets until the moment of the research process.

2.2 Process

A. Materials: Each group of children were given 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 school teacher at the beginning of the process and handed over to the children for habituation.

B. General design: The teacher explained the object of the activity. Sh/e 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, bridges, roads etc), which they characterized as such either on their own initiative or in response to the teacher's questions or propositions. Whenever the children failed in their constructions, the teachers intervened in order to help them execute their plans and ideas. 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 students abandoned their work or when they started to play by using the rest of the material without the magnets. Interaction between children was preferred, 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 production and the exchange of the material they selected. Each group worked for approximately 25 minutes. The whole procedure did not take place in a classroom but in the school laboratory. For the purposes of the research the laboratory was organized in a specific way; all the children of 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 work of 3 groups was recorded and the films analyzed. From this analysis, we arrived at an observation protocol on the basis of which we recorded the activities of the 36 remaining subjects which participated in the procedure.

3. Results

The analysis of the findings has a qualitative character. We attempted to study not only the frequency of a specific achievement, but also the development of the activity as well as the recording and investigation of the situations under which the research took place (Nertivich, 2014). The axes on the basis of which we recorded our comments are the following: a) random discoveries by the children, b) accomplishment of activities based on children's constructions, c) new patterns after the finding of magnetic properties, d) completion of constructions with the help of teachers and e) resumption of initiatives after the intervention of teachers.

We considered our questions confirmed when the children, in collaboration among themselves or with the support of the teacher, succeeded:

1. working with a magnet in discovering attraction by distinguishing between magnetic and non-magnet materials and
2. working with two or more magnets by locating the mutual attractive and repulsive forces between the magnets.

A. Working with a magnet

At the start 39 out of 48 children discovered the attractive magnetic property. That is, by using a magnet they unintentionally attracted an iron object. They very often pulled it away and positioned it in a place 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, Fjodor by coincidence moved a magnet attracted some iron objects and he attributes magnetic attraction to some kind of "glue" which he tries to find by the touch. He touches the magnet and looks at his hand, while immediately afterwards she checked to see if the magnet "stuck" to his other hand.

Once the children discover the attractive force of the magnets, they start attracting various articles - usually the objects which happen to be near them. So they have the opportunity to see that the metallic clips are attracted by the magnet, while a plastic clip, for example, is not attracted despite continuous essays. This process of recognition is repeated several times and it obviously has the character of trials. Afterwards or at the same time, the children conceive some configurations and try to realize them. In fact, this constitutes the main part of the teaching activity. Gradually children begin to use the whole material in their effort to promote their plans. For example, by placing drawing pins at the end of a magnet bar they form a "knife", by supporting a metallic bar vertically to the one pole of the magnet bar they form an "L", and by using clips they make a "monster". As children become familiar with the material and with the attractive property the patterns multiply and we now have a set of several diverse activities with the same materials: “animals” "roads", "bridges", and "tables" as well as a number of indefinite forms. It is significant 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. Gennady, for instance, made a complicated construction out of such objects. When the teacher asked him to explain what he had made, after thinking for a while, he answered: "It is something to think like engineers".

The creation of complex projects also facilitates cooperation among children. 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, Marusya constructs a “spaceship” positioning clips on a lamellar magnet. When she tries to put props that the spaceship to stand upright, he uses little plastic objects which do not "stick", as she discovers after a few failed tries.

The teacher then urges Marusya to use metallic clips so as to complete the task he has planned.

Six 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 always they were very fascinated; 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, Miroslava, after watching the activity of the other children some minutes without acting at all, she got a lamellar magnet, picked some small iron objects and placed in the arms and she said “I made a flower”.

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.

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

B. Working with two or more 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 fascinated. At first they insist on "sticking" together the two poles which are repulsed. Ninockha, for example, after trying in every possible way to join two rectilinear magnets which repulse each other, seems to be giving up this idea. Fortuitously, as the one magnet turns in her hand, she achieves his aim. That is, she succeeds and at the same time distinguishes between attraction and repulsion, because when she later attempts to repeat her original plan, she immediately rotates the magnet in order to change the pole as soon as she perceives the repulsion.

After the initial discovery of repulsion, 42 children organized work plans during which was 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, “hunters” chasing “animals” by using the repulsive powers of magnets or even "dancing" magnets.

The remaining 6 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. Consequently, we cannot claim that they discovered repulsion.

4. Discussion

The success of the example we gave shows that Piagetian strategies may be a highly satisfactory teaching framework for the development of effective activities in physical sciences with respect to lower primary education, as in other studies we have seen the same for pre-school education (Kampeza & Ravanis, 2009; Nertivich, 2014; Ntalakoura & Ravanis, 2014; Rodriguez, 2015; Kada & Ravanis, 2016; Tin, 2017). Respect towards both independence and the individual rate of little children's development, encouragement of curiosity and creativity, effective implementation in primary school classes as well as teachers' systematic activity are important advantages of these methods.

Nevertheless, 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 (Rogers & Voelker, 1970; Thomson & Voelker, 1970; Ravanis & Papamichaël, 1995; Waite-Stupiansky, 1997; Ravanis, Papamichaël & Koulaidis, 2002; Howe, Tolmie, Thurston, Topping et al., 2007; Grigorovitch, 2014, 2015; Rodriguez & Castro, 2016). Indeed, the comparison between the results of these approaches and Piagetian strategy demonstrates the most suitable strategy for the cognitive progress of lower primary school children. Anyhow, before they are incorporated into some curriculum, the suggested activities should have been previously tested through research processes in both experimental environment and actual lower primary classes.

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